COMMONWEALTH OF PENNSYLVANIA.

REPORT

OF THE

COMMISSIONER FOR THE RESTORATION

OF THE

INLAND FISHERIES,

FOR THE YEAR 1871;

INCLUDING HIS

SPECIAL REPORT TO THE SENATE

ON THE

SUBJECT OF FISH LADDERS.

HARRISBURG:
B. SINGERLY, STATE PRINTER.
1872.

PU.

COMMUNICATION.

EXECUTIVE CHAMBER,
Harrisburg, January 16, 1872.

To the Senate and House of Representatives:

GENTLEMEN:—I have the honor to transmit herewith, for the information of the Legislature, the annual report of Colonel James Worrall, Fish Commissioner of the State, upon the restoration of the inland fisheries of the Commonwealth. The subject is one of great interest and importance. The Commissioner treats it with his usual learning and ability, and I bespeak for his report and recommendations the careful consideration of your honorable bodies.

JNO. W. GEARY.

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REPORT.

HARRISBURG, *Jan.* 15, 1872.

To his Excellency JOHN W. GEARY,
Governor of Pennsylvania:

SIR:—It is with satisfaction I have the honor to report on the subject of the restoration of the inland fisheries; that the year past gives us every reason to hope for ultimate success.

As may be seen by my previous reports, we commenced the experiment for their restoration, by the erection of a fish-way in the Columbia dam. This work was completed in the year 1866, and brought into operation in 1867.

The very first year of its trial, it was successful beyond expectation; for a very respectable catch of shad was made in the Susquehanna above the dam in 1867. The fish-way was aided in some degree by an abrasion of the dam, to a considerable extent, near the Lancaster county shore, by an ice flood which took place that year, and by high water during the run of these migratory fish.

Up to this period it had been generally supposed that shad came to maturity in a single season, an idea not even yet entirely dispelled. But the minds of intelligent men were brought to bear upon this subject, in all the States north of Pennsylvania, and the opinion began to prevail, after a close examination of their habits, that they did not return to their place of spawning until the second, third or even fourth year after their birth. The two year olds were so small as to be scarcely worth taking, whilst the three and four year olds were the average fish of our markets.

The largest run of shad that has been known to pass the Columbia dam was that of 1867, and the largest return of fish spawned by that run was naturally to be looked for in 1870 and 1871, according to the opinion recently formed as to the period during which they remained at sea. From the moment of the construction of the fish-way, and the passage of the law that required it to be built, the fisheries of the Susquehanna have improved. But it remained for the return of the fourth year to prove that it has had a most beneficial result.

The law of 1866 provided that no fishing should be allowed within half a mile of any of the dams through which fish-ways were erected, and in 1867 the Columbia fish-way was allowed a fair chance. So that the catch, as has been stated, above the dam, was numerous beyond expectation in that year. But local pressure was brought to bear on the Legislature of 1868, and the half mile was reduced to two hundred yards. The effect of this was to crowd the fish-way with fisheries to such an extent as to make it surprising that any fish could get through it at all. I have described a system of fishing with dip nets in my last report, which must have operated most seriously to reduce the numbers that could even approach our passage way, and since 1868, then the catch above the dam has been much smaller than that of 1867. But this is a state of things that can be remedied. The half mile can be reinstated, and the people above the dam have their fair proportion of the fishing. The great fact of 1871 is the extraordinary increase in the Susquehanna fishing, from its mouth to the dam at Columbia.

It is believed, and I think any fair mind will confess with reason, to be due to the extra natural spawning of 1867, afforded by the respectable number of fish that found their way to the fine spawning ground between Columbia and Duncan's Island.

Very soon after I was appointed Commissioner of fisheries, I discovered that unfair, unsportsmanlike, nay piratical fishing was quite as much the cause of the deterioration of this great material interest as even the erection of the navigation dams. I assisted in preparing the earliest of the laws, and these laws made fight against the fish baskets or kiddles. Year after year clauses were introduced for their suppression. In my last report I gave a history of their demolition in England, which took place as long ago as in the thirteenth century. No law, however, seemed as if it could reach them in Pennsylvania, until at last, at the last session of the Legislature, a statute was enacted making it mandatory upon the sheriffs of the riparian counties to tear them down, aided, if necessary, by a *posse comitatus*, and at last they are beginning to disappear, although they are not quite extirpated yet.

The earlier laws have had some effect to be sure. In 1870 Lancaster county showed some energy in their destruction below Columbia, and not too soon, for many of them were thus got out of the way, giving an opportunity for the product of the increased run of 1871 to reach the ocean.

Up to 1870 a Columbia shad of any size used to bring at Columbia, within a couple of miles of where it was caught, the biggest end of a dollar, and some of them brought even more than a dollar a piece. In 1871 the finest Columbia shad were hawked in the market at Harrisburg, thirty miles from the fisheries, at considerably less than a dollar the pair.

The catch at Columbia considerably exceeded 100,000; and it is entirely

fair to conclude that this has been caused by the erection of our fish-way at Columbia, and the fight that has been made against piratical fishing.

We have fortunately collateral evidence going to prove this. In the very year that the opening at Columbia was made, shad were spawned artificially in the Connecticut, at the expense of the State, by Seth Green, of New York, (the inventor of artificial shad culture,) to the extent of two millions, and in the corresponding year 1871 we find the catch in the Connecticut exceeding any take for as far back as the year 1802, thus by a single experiment making up the losses in that river which had been increasing yearly for over three score years. Green, about the same time, spawned some shad in the Hudson, and in the Hudson we found that in 1871 the catch increased to such an extent as to lower the price of the fish in New York city from fifty and sixty cents down to an average of say thirty-five cents.

But no experiment of the kind was made in the Delaware river, nor was the habit of fishing disturbed there at all, and in the Delaware no marked increase in the catch was observable in the year 1871.

There surely is enough here to predicate an opinion that if the shad be allowed any the least chance, naturally or artificially, that they will multiply so as to satisfy almost any demand that the population along the streams are likely to make upon them.

I have refrained from making any recommendation of expense to bring about this desirable result until I could feel perfectly justified in doing so. But I think the time has now come to recommend a small expenditure on the part of the State in this direction.

But it is not only shad that are beginning to reward us with some result for our endeavors to rehabilitate our streams.

There are numerous other fish belonging of right to these water courses, and one species at least, which has recently been introduced, which will be equally increased in numbers. The list of fish indiginous to the Susquehanna and the Delaware, all of which are good substantial food, has been stated as reaching over thirty. Of these, there are two which are beginning to re-appear, and were caught in appreciable numbers during the year 1871, in the neighborhood of Harrisburg. These are the wellknown yellow perch and the rock fish.

The Potomac black bass, or rather, indeed, the black bass of the western rivers, first introduced into the Potomac, and then into the Susquehanna, are decidedly increasing. The number of black bass brought here from the Potomac, within the last three years, cannot have exceeded three hundred. Yet there is scarcely a net taken up in the reach of the river, in this neighborhood, or in the fifty miles from Columbia to Duncan's Island, at this time, in which cannot be found some of the progeny of that very

small number. And, indeed, some of the adults have made their way through the Duncan's Island or Clark's Ferry navigation schute, and have been taken in the vicinity of Selinsgrove and Sunbury. Nay, one or two have been reported to have been taken in the North Branch, *above* Sunbury. I am pleased to report that the fishermen, generally, return these fish to the stream when caught alive. But those that are caught in the fish baskets are sure to die, as many of them have done unfortunately. The magnificent Susquehanna salmon, improperly so called, being in reality a pike perch, somewhat resembling, I believe, the mascalonge of the St. Lawrence, since we have commenced our fight against the fish baskets, has increased quite appreciably.

I find amongst my excerpts, an able anonymous article, culled from one of the Philadelphia papers, in which the fish of our waters are treated of. From this I give you the following list; and when we consider that there is absolutely nothing to be done but to observe the very reasonable laws, which the Legislature has passed on the subject, to increase the numbers of these, so that they can be bought and used by the poorest of our riparian inhabitants, surely every citizen ought to feel bound to have the laws enforced, and the Legislature should render all the aid that may reasonably be asked of it, to bring about so desirable a result.

I quote from the article as follows:

"There are at least one hundred and twenty species of fresh water fishes in the waters of Pennsylvania, omitting those of Lake Erie, of which seventy-six species are important as food. Thirty-one species exist in the Delaware and its tributaries, which are either now used as food or will be at some future time. About the same number are found in the Susquehanna, while there are forty-one inhabiting the Allegheny and its branches. When we reflect that each female of these species spawns several thousands or hundreds of thousands of eggs in a season, we can readily estimate the great importance this crop might be to us, as a source of cheap animal food, were it cultivated to the extent of the capacity of our streams.

"That capacity in Pennsylvania is very great, for it depends chiefly on the supply of food for fishes furnished by nature. This is ultimately derived from a strong vegetation, either directly or through the insects which feed upon it, or the fishes thus nourished as food for the carniverous species. Ultimately, then, a productive soil is as much the condition of fish production as of any other, and thus our State possesses, evidently, extensive advantages in this respect.

"Some of these species migrate to salt water in autumn, and remain there during the winter; others descend the creeks to the rivers, and the rivers to their deeper waters, and congregate in them during cold weather; others remain all winter in their usual haunts, burying themselves in the mud,

and undergoing a kind of hybernation, while some, for example, certain catfish, do not take even this precaution. With a few exceptions, on the advent of spring, and the breaking up of the ice, they ascend to the upper and clear waters, or to the gravelly bottoms, to deposit their spawn. The exceptions are the eels and the trout. The former descend the rivers in autumn, and deposit their eggs in salt water; the latter spawn in the upper waters, in late autumn, prior to their riverward, or in the case of the salmon, seaward migration. Of course no fishing is (or ought to be) permitted by law, during the months of spawning.

"Where the fishes avoid dams and other obstructions, by fish-ways, (or navigation sluices,) these should be especially guarded, to prevent the wholesale destruction which can be inflicted upon them at such times."

In speaking of the different species, the writer goes on, excluding from his list the *Alosæ*, or shad tribe, as being well known to most readers.

"We mention here that an Anchovy (*Engraulis Vittalus*) visits Delaware river and bay in immense numbers every spring, and might furnish quite as large a supply of food as the European species of the same name."

Then follow the salmon family, of which the brook trout and the sea salmon are the most important. Although experiments are being tried with this latter delicious and magnificent species, the writer does not place much hope in their success south of the Hudson, and fears that it will never be an important feature of the Delaware and Susquehanna fisheries. Let the experiments, however, go on, there is nothing like trying, though southern latitudes have a tendency to dwarf and otherwise deteriorate the northern tribes of fish.

The white fish, however, of the lakes, might be cultivated in various parts of Pennsylvania, and perhaps would succeed in our large eastern rivers.

Then comes the perch genus, of which the pike perch or Susquehanna salmon is about the best. These, as has been stated, are showing a decided increase in the Susquehanna, and they were not originally found in it but were introduced into the upper waters in the State of New York. There is a smaller species, almost as good, found in the Allegheny and its tributaries, which might be introduced into the Susquehanna without any difficulty, and both might be placed in the Delaware.

Then we have the yellow and white perch and the rock or striped bass, so well known in both our great streams. These will undoubtedly increase when unfair fishing shall have been put down. Then there is the black bass and the white perch, or moon perch of the Allegheny, which can as easily be transported to our eastern waters if it is not found to increase from the occasional stragglers already caught in the Susquehanna. Even

the smaller sun fishes have considerable market value, and with the others will increase and multiply.

To these may be added the pike, the pickerel, the eel, and different kinds of catfish, which can be brought over from the Ohio. This brings the number in the list to about twenty, about three-fourths of which already exist in our streams. But there are the carp, the suckers, the chubs, the mullet, now not so much valued, but all of which will add more or less to the increase of this kind of food so much repressed by sheer neglect on the part of our people.

There is a species called the buffalo, which is to be found in the western waters, and used as food. This attains quite a large size, and is generally taken by the spear, an attractive mode of fishing to some sportsmen.

The sucker family, although not great favorites, increase wonderfully, when they are allowed free passage up and down the streams, and although man may reject them, they are much sought after by the piscivorous tribes; and as many of the predatory fish are the choice of the epicure, the protection of the less attractive kinds will help to feed and increase the numbers of these more refined species.

We have struck at the root of the evil, which has brought about the deterioration of our fisheries, and although four or five years have elapsed since the war began, we have no reason to despair of success. The progress has been slow, but it has been sure. It took thirty years to bring about the scarcity, but it will not take, by any means, so long to replenish our streams.

There have been two causes of the trouble: First, the erection of the navigation dams; second, unfair fishing. The latter has been much the more injurious of the two. When the dams were erected, the people simply concluded that the fisheries were destroyed, and thenceforth took little or no interest in the subject; leaving the streams to the depredations of whomsoever might choose to ransack them, and destroy their products.

Unfair fishing, of every kind, ran riot, and the streams became almost entirely depleted.

Now the navigation shutes always served as a sort of fish-way, and had not the fish baskets destroyed the newly spawned fry, there would still have been a crop (so to speak) every year. But the subject was utterly neglected by the more respectable of the people, and left in the hands of men, reckless of the consequence of their system of fishing, whereby the rivers were almost abandoned by their inhabitants.

The restoration movement has proved that if fair fishing be once re-established, plentiful hauls will be the result, and all varieties will be increased.

It has also proved that fish ladders can be made, through which every variety can make their way; so that without injuring the dams, for the

purpose for which they were erected, those dams can be made to cease being obstacles to the passage of fish. The restoration movement has also proved that many varieties of fish can be increased indefinitely, almost infinitely, by artificial spawning; and has proved that many varieties can be transplanted, alive, from one stream to another, so that within a reasonable zone of latitude on our continent, all the various kinds of fish can be enjoyed by the inhabitants neighboring the streams.

But our great streams fall under the jurisdiction of various States, and it is required that the fishery laws of these States shall be assimilated as far as practicable.

This we have sought to bring about, but, as yet, without success. Concurrent legislation between New Jersey and Pennsylvania failed last year in consequence of a clashing of interests on the subject of the oyster beds in the Delaware bay. Let us hope that all difficulties will be got over during this session of the Legislatures of the two States, and that all will yet be well.

Delaware and New Jersey agreed last year, but Pennsylvania feeling somewhat hurt at the course pursued in New Jersey in reference to the oyster beds mentioned, took no interest in the other legislation, and the subject was deferred.

The laws which have been enacted here as to fish baskets, &c., in the Susquehanna, will be brought to the attention of the Legislature of Maryland at its present session; and as Maryland already begins to perceive the benefit of them even on her own fisheries, not interrupted by dams, there is strong reason to hope that coincident legislation will be enacted in that State. When the Susquehanna will be cleared from its mouth to the borders of New York, and the new era of our inland fisheries will be inaugurated, thus by far the greater of the two causes of failure in our fisheries will be disposed of. The next thing to be done will be the erection of fish-ways. The fish-way that we now possess has been more successful as a passage for shad than any other erection of the kind as yet constructed in this country. On this subject I have been ordered by the Senate to make report specially, in writing, in my present annual report. I make the report through your Excellency, as the order requires that it shall be in my annual report, but as it is a special order of the Senate, I shall address it to that honorable body, requesting your Excellency to present it, in connection with this my regular annual report.

I do not hear much complaint from the Delaware on the subject of fish baskets this year. The good sense of the owners themselves is beginning to regard them with disapprobation, and although our laws against them might have been "got round" perhaps by people so disposed on account of

the joint riparianism of New Jersey and Pennsylvania. There are but few of them left.

The black bass set free in the Delaware, near Easton, last year, to the number of five or seven hundred, I am informed by one of the New Jersey commissioners, "have been heard from, from Fort Delaware to Port Jarvis." This is surely very satisfactory, as the distance embraces hundreds of miles. There are no dams in the Delaware from the New York line to its mouth, and, therefore, the failure of the fisheries on that river has been caused exclusively by unfair fishing and over-fishing. There is really but little to do to completely re-instate the fisheries of that grand stream. Concurrent laws would have a beneficial effect on both sides of the river; there is no fishing interest that would be injured by them. A statute of three or four clauses would cover the whole ground—the evils to be remedied can be specified in a very few words, as thus:

1st. Regulate gill-net fishing, prescribing the size of the meshes, requiring uniformity, &c.

2d. Provide for some few hours of "close time," i. e. prescribe a period in each week in which there shall be no fishing, so that the fish may have some chance to reach their spawning grounds; or even let the sacred Sabbath hours, commencing at sunset on Saturday and ending at sunrise on Monday, be made a close time. Such a provision as this ought to be enforced in respect to the usages of christianity alone, without reference to the material interest.

3d. Prescribe a period in the summer to be agreed upon when all fishing for shad shall stop.

4th. Let all systems of fishing, which destroy the smaller fry incidentally, and for the sake of taking the adult varieties, be stopped.

The above four clauses, properly arranged into a statute, would cover the whole ground, with an additional clause providing for the due enforcement of the law.

I understand that the commissioners of New Jersey, encouraged by the success of our northern neighbors, will recommend an expenditure of a few thousand dollars in artificially spawning shad this year, notwithstanding that our concurrent legislation is yet imperfect. I would recommend Pennsylvania to do at least as much as New Jersey shall be willing to do in that line. Seth Green says that he can bring so many millions of young shad to life, that if the river be clear of dams, "you can't fish it down if you were to try," by which I understand him to mean that he would dare the worst that gill netting and fish baskets could do. But a slight allowance should be made for his enthusiasm, notwithstanding his splendid successes; and the indiscriminate and ill-regulated systems of fishing should be provided against before going to the expense of artificial spawning.

If the regulations recommended be carried into effect, *success is certain*, and the Delaware like the Connecticut can be made to show a catch greater than any since 1802, or to a period in the past "wherein the memory of man goeth not to the contrary."

New York has shown great enterprise in the restoration and propagation movements; but she is somewhat differently situated from Pennsylvania. She has some six or seven hundred beautiful inland lakes, and her attention has been turned to stocking these.

The State has established a hatching house, whence great numbers of her prime fishes have been distributed in the form of ova and of fry.

These have been distributed amongst her lakes and streams, and we shall come in for our share in time, of those which are placed in the upper waters of the Susquehanna. Amongst the list distributed, I find that "four hundred bass" have been placed in water that passes through our State, and reaches the Chesapeake. There is no danger but what these will eventually work down stream, and be caught at our very doors. Besides this little supply, Mr. Green made us a present the other day, of some six hundred salmon trout ova. These, as we have no hatching house belonging to the State, I have had placed in private hands at a hatching establishment in the neighborhood of Harrisburg, under the charge of Messrs. Seiler and M'Conkey, with the understanding that when they reach a size that will warrant their being trusted to their own resources, they shall be placed in the Susquehanna. This must be regarded as a complimentary present from New York to Pennsylvania. Perhaps as we get on, and have a hatching house of our own, we may be able to return the compliment.

I find that a plant of black bass, taken from the Potomac at Cumberland, and placed in the Raystown Branch of the Juniata, some years ago, has turned out to be a complete success. These bass, many of them, have reached to several pounds in weight, and can be caught in abundance in the sequestered loops and bends of that beautiful stream below Bedford. On the main Juniata, some were placed within a year or two. I am afraid that the war against fish baskets has not been prosecuted there with quite the vigor which has been exhibited by our Susquehanna sheriffs. Let me assure the people of that section that if they want bass or any other fish in their stream, their cry must be, "down with the kiddles;" there can be no success where those vile contrivances are allowed.

Now what we want on the Susquehanna, is pretty much what we want on the Delaware. We must have a close time on the lower waters. We must open more of our dams. We must thoroughly repress all unfair fishing, and then let us propagate. We know that we can make fish ladders, for we have made one that has met with fair success; all the rest is easy. We have Maryland to deal with on the Susquehanna, as we have

New Jersey on the Delaware. I am given to understand that the best of feeling exists in Maryland, and I am already in correspondence with a prominent fisherman on the lower Susquehanna, who says he doubts not that all reasonable concurrent legislation can be attained.

I close my report to your Excellency, by an imperfect list of the fishes which we might have in abundance in our great streams. Yet imperfect as it is, what a boon it would be to our people were these fish, or even half of them, to be had in our markets, at reasonable prices.

A LIST

Of some of the tribes of fishes, a portion of which are, and all of which might become inhabitants of the Delaware and Susquehanna rivers and their tributaries, in the riparian States of Maryland, Delaware, Pennsylvania, New Jersey and New York. (Some of the more familiar generic names are given in italics.)

The shad, alewife* and herring. (*Alosæ.*)
The Delaware anchovy. (*Engraulis Vittalus.*)†
The sea salmon* and brook trout. (*Salmonidæ.*)
The white fish.* (*Coregonus.*)
The pike perch, 2 species. (*Percidæ.*)
The yellow perch. (*Percidæ.*)
The rock and white bass.
The black bass.
The white or moon perch of the Allegheny.
The sunfish, 3 species (at least.)
The pike, 3 species (at least.) (*Esox-socidæ.*)
The pickerel.
The eel, 2 or 3 species.
The catfish, at least 3 species.
The carp, sucker, mullet, chub, buffalo, &c., pluralities of each.

There are over thirty, some of which are, as stated, now to be found in the streams mentioned, but all of which might be made plentiful in them, and it is so easy. For instance, most of the fish of the Allegheny and the Monongahela, can be got at Pittsburg alive.

For a five dollar bill you could buy a tin vessel, and fill it with any one of the species attainable there, by giving word to the fisherman, at the market, a day or so before hand; and probably without changing the water more than once, say at Altoona, empty your vessel and its fish into the Susquehanna, in eight hours after the purchase was made. Black bass

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* Uncertain but should be tried.

† A sea fish, but which might be transplanted to the Chesapeake bay.

were introduced to, (and now fill the Potomac) precisely in that way, and they were brought from the Potomac to the Susquehanna, bidding fair to fill it in the same manner.

Almost any species can be brought across the mountains, and *settled* in our streams, for about $100 for each kind. If we remain much longer without disseminating these excellent species, when it can be done so cheaply, it will be our own fault.

Then, again, there are some kinds that can be sent in the form of ova, by mail, even in a letter, the postage of which would probably not reach fifty cents.

The 600 salmon trout I got in the form of ova, from York State, the other day, tin vessel, transportation and all, did not amount to $2 00. Of course, the eggs had a market value, but that was made a present from New York to Pennsylvania. But supposing they came from a private hatching house, the whole plant could hardly have cost more than $20 or $30, at the highest.

Now there are catfish in the Ohio that reach over a hundred weight. Why might not we have a few of those old flappers to give variety to our Susquehanna waters? It is as easy to transplant fish as it is to transplant potatoes. But you must pay some attention to your fish after transplanting; you must watch them and care for them, and not allow them to be destroyed by pirates, as you must prevent your potatoes from being rooted up by hogs. Let us start this thing; let every respectable town on our waters have at least one "kettle of fish" brought across the mountains and flung into the Juniata, the Susquehanna, or some of their tributaries; then down with the kiddles, open the dams, and our whole population will share, and share alike, in this cheap, excellent and various food.

I must now proceed to my report on fish-ways to the Senate.

I am sir,

Very respectfully,

Your obedient servant,

JAMES WORRALL.

210237

REPORT.

To the Honorable the Senate of Pennsylvania, in session at Harrisburg, A. D. 1872:

GENTLEMEN:—About the first of last June I received a note from the Chief Clerk, Mr. Ziegler, stating that the following resolution had unanimously passed the Senate:

Resolved, That the Fish Commissioner of the Commonwealth, in his annual report, is hereby requested to make or cause to be made an estimate of the probable cost of constructing and putting into the several dams in the Juniata, Lehigh and Susquehanna rivers, and their branches, suitable and proper fish-ways to admit of the passage of fish, and report the same in writing to the Senate at the next session of the Legislature.—*Extract from the Journal.*

As the whole subject of fish-ways is comparatively new in this country, I determined, in endeavoring to fulfil the request of your honorable body, to make diligent inquiry and ascertain as nearly as practicable the best form which had been attained for fish-ways in the United States, and make an estimate of the cost of such form, and in order to give satisfaction as to the probable correctness of my estimate, and to show how I came to my conclusions as to the best form, I have deemed it proper to give a short history of the adoption of the fish-ways, with some account of their success, both where they originated and where they have been established in our own country. In doing this it will, I think, not be out of place to accompany my report with some diagrams taken from the best authorities I can find, comparing the plan adopted in Pennsylvania, which, differing in some respects from the others, has not been without its fair measure of success.

Although fish culture, *i. e.*, artificial propagation, is an old art. Indeed, it was practised by the ancients and lost, but has been recovered in modern times, and brought to its present success, since the coming in of the present century. Yet fish ladders or passes don't seem to have a history extending back over thirty or forty years. The most perfect in Europe, are two, which were constructed in Ireland, and for the purpose of conveying an idea what a fish-way is, I give the plans of those two, for which I am indebted to the report of the Maine Commissioners, who copied them from the Irish authority.

EXPLANATION OF PLATE 1.

FIG. 1.—Fish-way for salmon at Balisodare, Ireland, over a precipitous water-fall of 19¼ feet. No salmon had ever previously ascended these falls, but since the erection of the fish-way many thousands of salmon have been annually caught above them. E, where the water enters. G, where the salmon enter. The arrows show the direction of the flow of water.

FIG. 2.—Fish-way for salmon at Galway, Ireland. This is over a dam erected for purposes of milling and navigation and the most of the water passes off in the conduits. The fish-way uses only the one hundred and sixtieth part of the water in the summer season. D, dam. E, entrance for water. G, entrance for salmon. This fish-way has been in operation sixteen years, and during that time the annual product of the fishery in the river has risen from 603 salmon to 20,512 salmon.

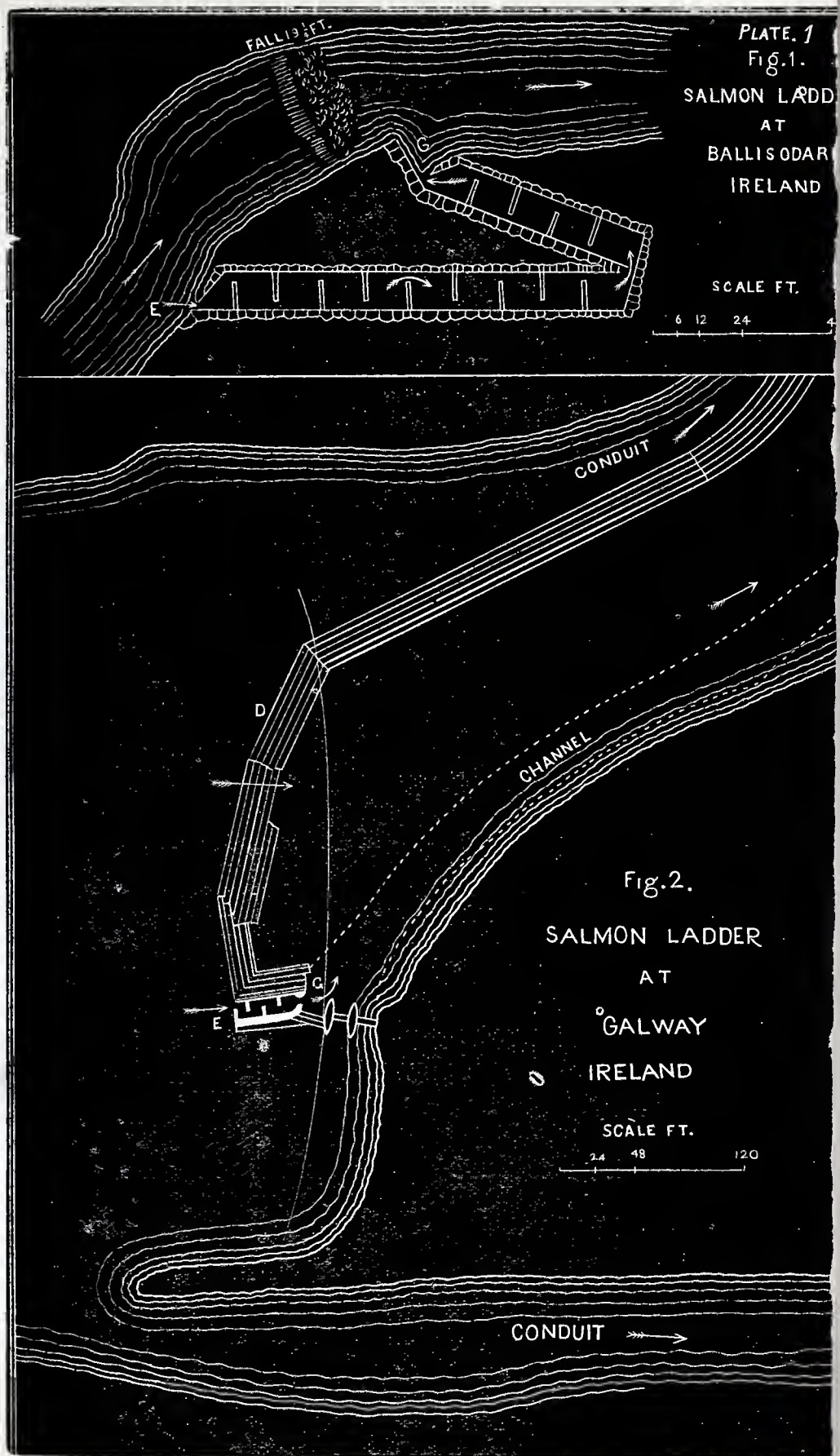


PLATE. 1

Fig.1.

SALMON LADD

AT

BALLISODAR

IRELAND

Fig.2.

SALMON LADDER

AT

GALWAY

IRELAND

SCALE FT.

24 48 120

Although these fish-ways or ladders, as Mr. Roberts, the Irish Engineer, calls them, are intended for salmon, a much bolder, more powerful and persistent fish than the shad, the principles of construction apply, to a certain extent, to a fish-way for shad. In the description of our American fish-ways, the modifications will be perceived, and these Irish plans will be interesting, and will tend to impress the idea of a fish-way on the mind of a person seeking to understand the subject.

Mr. Roberts* gives the following description:

Drawing No. 1, (pl. 1, fig. 1, of this report,) is a plan of the ladder on the Ballysodare fish-way, in the county of Sligo. The obstruction here consists of a natural rock; the ascent is 19¼ feet, and almost vertical, over hich now salmon had ever previously passed. The length of the salmon ladder from inlet to outlet, is 174 feet.

It is divided into 15 pools, each of which is 10 feet wide and 11 feet long, and the average depth of water ponded in them is 15 inches. The inlet to this ladder is only 10 inches wide, with a depth of 2½ feet of water flowing through it, at the ordinary level of the river.

Mr. Roberts's second drawing, being so like drawing No. 1, I do not reproduce it.

Drawing No. 3. (Plate 1, Fig 2, of this report) is a plan of the ladder in the weir at Galway, on the river Corrib. This weir was formed for the purpose of maintaining the level of the water for navigation and mill power. The ascent, at the ordinary level of the river, is 5 feet. The length of the ladder is 46 feet, which is divided into 5 pools, each being nearly 10 feet square, and the average depth of water in them is 14 inches. The inlet is 2 feet wide, with a depth of 2 feet of water flowing through it, at the ordinary summer level.

These ladders are admitted to be most perfect and successful.

There is no other means for the fish to pass up, and the upper reaches have by the means of these ways exclusively, been thoroughly stocked with salmon.

These Irish ladders, and similar structures in Scotland, gave rise to the Foster fish-way, which was first constructed in Maine by the lamented Mr. N. W. Foster, now no more, he having been in the latter years of his life a commissioner for that State. In my report for 1868 I gave a sketch of the Foster fish-way, taken from the Massachusetts report.

It was soon found necessary to modify this fish-way, as it had a tendency to create eddies, indeed small whirlpools, in which the fish obeying their instinct to swim against the current, used to circumgyrate, so to speak, until they would become giddy and would float back to the lower reach exhausted. The Massachusetts and other New England commissioners soon remedied

*Samuel U. Roberts, Esq., M. I. C. E.

this, as it was very easy to do, by constructing the bulkheads in such manner as to lessen the tendency to form whirlpools; and they have now produced a fish-way which has been already successful for the passage of all their anadromous fishes, except shad, but the present plan which I shall now give in this report, they fully expect will be equally practicable for the latter variety.

In producing a plan of the Massachusetts fish-way, I give the original remarks of Col. Theodore Lyman, a very high authority, which accompanied the copy furnished to me by the Massachusetts Commissioners.

"The first condition of a good fish-way is this: *that the water should flow for its whole length with a uniform swiftness.* When this condition is answered, the fish being opposed by a constant pressure, has no disposition either to stop or to turn back, but pushes directly through. If it were possible to use a simple trough leading from the crest of the fall straight to the water below, we should have the best sort of fish-way. But since water flowing in a simple inclined trough, moves with an increasing velocity, it is necessary to introduce bulkheads which practically close the trough and check the flow, which thus takes on a serpentine form and moves with a regular speed and direction, except at the angles of the bulkheads where there are small eddies."

He then goes on to explain the plate, (plate 2 of this report,) fig. 1—an Improved "Foster" Fish-way. "This pass, contrived by the late Nathan W. Foster, Fishery Commissioner of Maine, and perfected in its details by my colleague, E. A. Brackett, is usually built of plank and timber, but it can be as well made with masonry. This figure shows it in elevation with the head set *into* the face of the dam and the foot resting in the river below. It will be observed that the floor is a uniformly inclined plane without depressions to form pools or resting places. The floor of a fish-way should be as *smooth* as possible; a still pool or a large eddy is a temptation to the fish to loiter or to turn back, and the old idea of making such pools is an error. Fig. 2 shows the same in plan with the cross bulkheads A A, and the girders which brace the plank sides. The upper entrance is at B and the lower one at C. Fig. 3 shows a "return" fish-way, that is one which doubles on itself and comes back toward its starting line. Fig. 4 shows the manner of arranging the bulkheads at the "return," so as to have a uniform flow. Figs. 5 and 6 are drawings somewhat enlarged, showing details of construction. Fig. 7 shows the "slide" or gate by which the volume of water is regulated at the head of the fish-way. (B.) (See also B, fig. 1.) Fig. 8 shows a section of the slide or gate, (S) which should never play up and down, but always sideways. The fish-way when not over 100 feet long may fall 1:10; when longer than that, it may fall 1:12 to 1:15. The width of the openings through the bulkheads should be about

PLAN OF FISHWAYS

AS BUILT BY THE

MASSACHUSETTS.

COMMISSIONERS

PLATE. 2

ELEVATION Fig 1

PLAN Fig. 2

Fig. 3

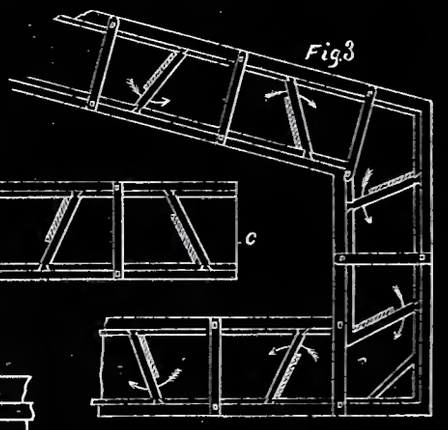


Fig. 5

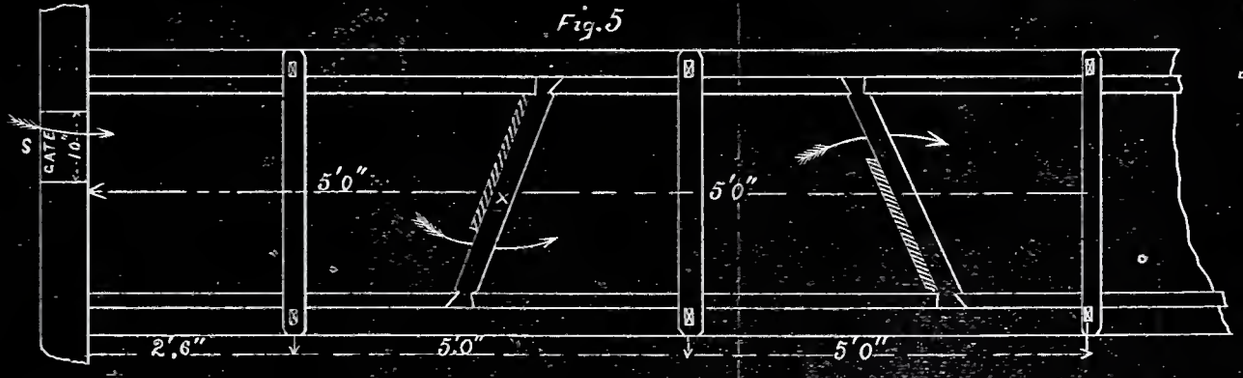


Fig. 4

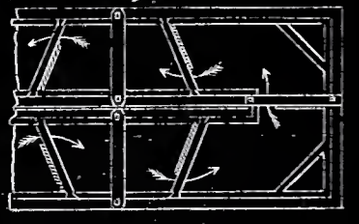


Fig 6

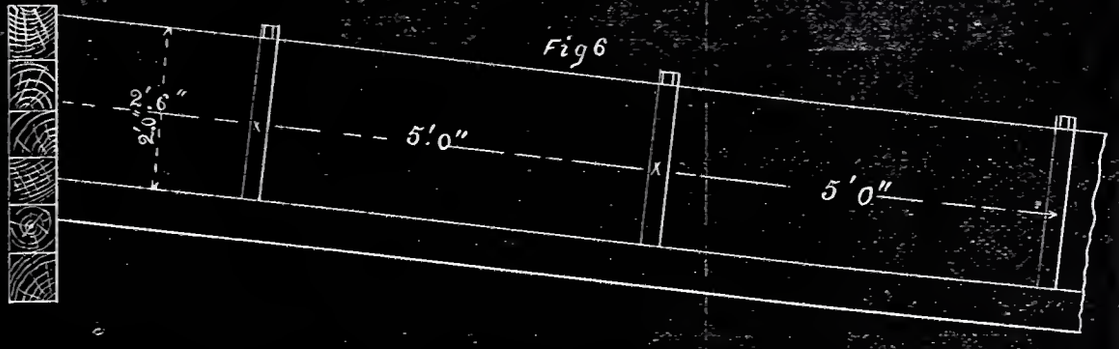
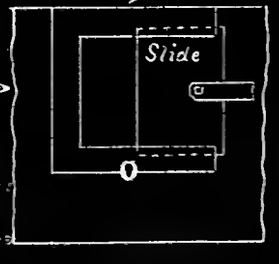


Fig. 7

Fig. 8



one-third the width of the fish-way. The width of the latter is usually $2\frac{1}{2}$ to 3 feet, and the width of the opening is therefore 10 to 12 inches."

Fishways of this form have had complete success with salmon, (*Salmo salar*,) trout (*S. fontinalis*) and alewives, (*Alosa tyrannus*,) but have not yet been properly tested with shad. (*Alosa praestabilis.*) All the common fresh water fishes, (*Perca Leuciscus*,) *Custostomus*, *Anguilla*, &c., pass up with the greatest ease."

Thus I have the honor to lay before you, the American fish-way, with its latest improvements, as devised and adopted in the New England States.

Let us now return to Pennsylvania, and see what we have done here. It will be remembered that our fish-way was completed about at the same time that they were completing theirs, and, indeed, it was not without consulting them that we proceeded with ours.

Reflecting on the same subject, we had come to similar conclusions with them, namely, that a simple inclined trough would be about the best form to adopt, provided that the accelerated speed of the water could be reduced to a uniform velocity. They, at that time, supposed that shad could overcome an inclination of 1:10, but for perfect safety, I adopted 1:15, disregarding the steeper suggestion, which was not only made by them, but by the practical men in Pennsylvania, whom I consulted, and who also proposed 1:10.

It will be perceived that the gentler slope has since become the better opinion, and an inclination of "from 1:10 to 1:15," is recommended according to the length of the structure. For shad, I should adhere to the minimum slope, as it is certain that they are about the least persistent of the tribes which ascend our ladders.

Our fish-way, then, is precisely what has been recommended as the best, except that uniform velocity is effected by the water below the dam backing up into the aperture, which in dams as low as six feet in height it must almost always do, for the stream must be at least three or four feet in depth in front of and below the dam during the run of the shad, when the stream is commonly in a state of freshet. I have described this effect in one of my former reports.

We differ from them, besides, in another important respect.

Our trough is cut into the dam instead of being constructed in front of it. Thus it is almost impossible for the fish to miss it, as when they meet the obstacle of the dam, they move along it until they find the opposing current, against which their instinct prompts them to ascend.

When we come to consider dimensions, however, the American fish ladder appears to us to be almost ridiculously small; its width being measured in inches, and our streams being on their main stems often more than a mile in width.

How narrow an apperture a shad will ascend is not as yet known. One of the Massachusetts commissioners tells me that a few individual shad have been known to ascend the ladder at the Suffolk dam, (I think it is,) in the neighborhood of Boston, the ladder of which is of the small dimensions, inferred from Col. Lyman's description; but on the Susquehanna the narrowest width of our fish-way is 20 feet.

The plans submitted in this report, although indicating small dimensions, are correct in principle, and can be enlarged to suit any stream when that principle is once understood.

I will try to give in words what a true fish-way is, and with this definition and a consultation of the plans submitted, no intelligent millwright or dam-builder can be at a loss to go about its construction.

A fish-way then, for shad, is an inclined trough, either constructed in front of or cut into a dam or other permanent obstacle, (say a ledge of rocks, as in one of the Irish cases,) the inclination being 1:15, the bottom to be smooth. The accelerated force of the water, say two feet at least in depth, flowing through this trough, must be retarded and made uniform, either naturally or artificially. It can be so retarded naturally in dams of six feet high, or less, by the water below the dam backing into it, provided that water be three or more feet in depth during the run of the shad. But if this state of things does not exist, then it must be retarded artificially by the construction of bulkheads protruding alternately from the sides of the trough, in such manner as to give a serpentine direction to the current—a direction (as Mr. Brackett, who is an artist, and to whom is due these later improvements, described it to me,) something like the "line of beauty" of Hogarth, the great English painter. This line of beauty is gently undulating, but not mathematical. It will be a near enough description to say that if the line were composed of the curves of equal circular segments, reversing, alternately, the middle ordinate or versed sine, as it is sometimes called, of those segments, would be about $\frac{3}{16}$ the length of the chord. I have taken the pains to get this dimension from a small edition of Hogarth, belonging to a friend of mine.

The opening through which the water flows through this trough, should not be more or less than one-third of the width of the trough, and the bulkheads, constructed in the trough, should not be made at such angles as to create circular eddies in the corners, for these, as I have before mentioned, have a tendeney to mislead the fish, and tire them to exhaustion.

The water, as it flows, should not be allowed to reach such a velocity as to create bubbles of air. It should be "black water," as Mr. Bracket, the Commissioner, expressively said.

I am decidedly in favor of cutting into the dam in preference to building in front of it, though the latter method is certainly the cheaper of the two;

indeed, it would scarcely cost more than half or two-thirds what the incision plan would.

As to method of construction, let the above conditions be satisfied, and whatever construction will best stand the vicissitudes, the result of the regimen or habit of the stream, will answer. Let the opening be made in the channel up which the fish were known to have passed before the construction of the dam, and they are not likely to miss it. And if they were never known to have passed up, then let the opening be made in the main channel of the stream.

In a stream like the main Susquehanna, where the dam is low, like the Columbia dam, a clear trough of twenty feet wide will undoubtedly answer. A single opening in such a dam as that, the dam being a mile and a quarter long, is not enough. There should be another. Where dams are higher, the whole width should be thirty feet, and the serpentine current made ten feet wide.

On the West and North Branches, say as far up as Williamsport and Wilkesbarre, twenty-one and seven should be the dimensions; the same on the Juniata as far up as Lewistown, and so on the Lehigh up say to Allentown. But higher up these streams, and on the smaller branches of the Susquehanna, the dimension might be reduced to 15 and 5, and to 9 and 3. Through a lower dimension it is, I think, rather problematical whether shad would ascend. They are expected, however, in New England, even through smaller ladders. I should prefer to await the result rather than build, anticipating the advent of shad. All the other tribes, however, as Col. Lyman observes, have taken their ladders with ease.

We now have certain dimensions from the largest to the smallest that are likely to admit shad, and the best way to come at a statement of their probable cost is per foot rise of dam. The clear 20 feet trough, cut into the dam, may be estimated at $1,000 per foot rise; the 30 and 10, that is a trough 30 feet wide, calculated for a current of 10 feet, might cost something more, but may be put at the same, as the dam would be higher, and the ratio of height to width might bring the price per foot to an equality. The 21 and 7 would be, say $900 per foot rise; 15 and 5 would be $750, and 9 and 3, say $500. These prices are for incision ladders formed so as to be of no injury to the dam, and constructed substantially so as not to be injured by freshets.

The cost of ladders in front of the dams would be from 30 to 40 per cent. less, and can easily be so estimated.

These estimates are based upon the average condition of a dam and its surroundings, and may, therefore, be materially modified by favorable circumstances. It is often found, for instance, that a fish-way may be created around a dam or other impediment, in which case the cost might be very

materially reduced. There is one in the New England States that did not cost more than $150 per foot rise. The prices I give are *high* enough; they are more likely to be changed by reduction than by addition.

Calculating by these prices, then, the cost of accommodating "the Juniata, Lehigh and Susquehanna rivers, and their branches," with fish-ways, (confining ourselves to those branches embraced in the fish laws,) would be about as follows—and for the branches not so embraced it will be easy to deduce estimates from the prices heretofore stated—for any dam. These fish-ways, it must be remembered, are such as can be presumed to answer for shad; those for smaller fry would be proportionally lower, even as low as $150, as has been stated, per foot rise; and as the principles and modes of construction are the same as shown in these plans, the cost for any locality in the State can be easily come at, whilst it would be somewhat difficult to estimate what a full suit of fish-ways for all the main stems and branches of "the Juniata, Lehigh and Susquehanna" would reach:

The main stem of the Susquehanna, say from Columbia to Northumberland—including an additional ladder at Columbia—would cost	$20,000
The Swatara from its mouth to Jonestown	15,000
The Juniata from its mouth to Hollidaysburg	90,000
The Raystown Branch from its mouth to Bedford	15,000
The North Branch—Susquehanna—from Northumberland to Wilkesbarre*	6,000
The West Branch—Susquehanna—Bald Eagle Branch—from Northumberland to Lock Haven and Bellefonte	16,000
The whole amounting to	$162,000

At least 30 per cent. may be deducted from the above if the ladders are built in front of the dams, and it is believed that many circumstances may occur to reduce the estimate, whilst it is, as has been stated, not likely to be increased.

I have hesitated, heretofore, to recommend the State to go to any expense in this matter of the restoration of the fisheries, until I could feel certain that expense would be reimbursed by success. I have waited first to find the root of the evil, and then the remedy.

I have stated before, that in addition to the navigation dams, the cause of all the trouble has been unfair fishing. What little has been done, through great exertion, has been made to reduce this evil, and is already bearing its fruits. We see tribes returning to our rivers, which had al-

*As the dams above Wilkesbarre are expected soon to fall into disuse, there is no estimate made for them.

most disappeared, and new tribes are flourishing, and are likely to flourish. It is certain that openings or ladders can be made in or upon the dams, which shall be accessible to the fish. And it is certain that fish can be propagated artificially in almost infinite numbers. So that it seems not at all unreasonable to hope that our streams can be brought to their former fruitfulness. We have evidence of this in our own State, and in our neighboring States. A small expenditure of money, as has been seen, will re-habilitate the Susquehanna from Columbia to Wikesbarre, and say Milton or Williamsport. I would recommend *that* expenditure to be made.

The Delaware river, fortunately, is not crossed by a single impeding dam, until after the State line of New York is passed. Unfair fishing is gradually disappearing from that great stream, and it is hoped will soon disappear altogether.

New Jersey is to be asked for an appropriation, for the artificial propagation of shad in the Delaware. If our sister State makes such an appropriation, I would recommend Pennsylvania at least to equal that appropriation. New York has established a State hatching house, where all the useful fishes are artificially hatched, and thence distributed to the people of all parts of the State. Would it be out of the way for Pennsylvania to imitate this liberality? It is stated that an anchovy visits our Delaware bay in vast numbers every year. Here is a business, a production, a special commodity, that for the want of proper inquiry, we seem to be entirely ignorant of. The Delaware anchovy may not equal the Mediterranean species in value, but it can scarcely be valueless. The quantity of anchovies imported into this country is immense. Now, if we have them in our very estuaries, why need we import them? Let us learn to catch these fish in quantities, and pack them for our own use, and for sale to our neighbors, and to foreign nations.

The agitation of this subject has set men to thinking, and it is being discovered all over the country, how we have let this important interest dwindle nearly to nothing, whilst almost by a turn of the hand, it need not have suffered at all.

We have large numbers of our citizens engaged in the oyster trade, on the Delaware bay. The jealousy of a few of their own kind of men, engaged in the same pursuit, in a neighboring State, has taking advantage of some nominal territorial riparian rights, jeoparded the interests of these our fellow citizens. Here is a subject also for consideration.

But the whole matter should be placed in the hands of a competent commission, the commission of Pennsylvania having expired by limitation with the year 1871. It has been suggested that if it be re-established, it should consist of three in number, instead of one, as heretofore. I leave the matter without suggestion on my part, premising, however, that the other

States are represented in every case, by more than one member, in most cases by three; that the position has not been disdained by some of the first men in the land, and that in scarcely any case has the compensation been more than nominal, the Commissioners performing the duties efficiently and *con amore*. It is not advisable to make it a bait for the office-seeking portion of our fellow citizens. Such a commission would, no doubt, eventually succeed in re-establishing this very important branch of our material industries.

I have the honor to be, gentlemen,

Very respectfully,

Your obedient servant,

JAMES WORRALL.

POSTSCRIPT.

Private individuals have, during the past season, introduced black bass into the Schuylkill, the Brandywine and the Swatara, and an attempt has been made also on the Lehigh. I learn from the Representatives and Senators of those districts, that there is fair promise of success in each case, except that of the Lehigh, where some untoward accident prevented the arrival of the fish, or at least prevented their being set loose in the stream. I hear, as yet, of no failure where the fish have been placed alive in the new waters.

J. W.